REMARKS

Applicants have, by this amendment, canceled claims 26, 34 and 57, and amended claims 22, 28, 29, 31, 32, 40 and 58 in the above referenced patent application.

The Examiner requested that Applicants list the related applications on the first page of the Specification. Accordingly, Applicants have amended the Specification to include the related patent applications.

The Examiner objected to the drawings as not showing every feature of the claimed invention. Specifically, the Examiner asserted that none of the Figures illustrated the outer edges of the end surfaces of the pole pieces connected together to define a non-symmetrical diamond air gap. Applicants have added proposed FIGURE 12A, which illustrates the outer edges of the end surfaces of the pole pieces connected together to define a non-symmetrical diamond air gap. Applicants have also amended the Specification at pages 7 and 12 to make reference to FIGURE 12A. The Examiner also objected to the drawings as not showing intermediate areas of the end surfaces of the pole pieces having a different shape. FIGURE 13 illustrates intermediate areas of the end surfaces of the pole pieces having a different shape. Finally, the Examiner objected to the drawings as not showing the air gap filled with a low permeability material. Applicants have added proposed FIGURE 14A, which illustrates an air gap filled with a low permeability material. Applicants have also amended the Specification at pages 8 and 12 to make reference to FIGURE 14A. Applicants submit that the drawings show all of the features of the claimed invention.

Applicants noted that the Examiner crossed off the reference HU 182260 filed December 16, 1980 and published February 28, 1983. The submitted reference included an English abstract. A copy of HU 182260 and the English abstract is enclosed for the Examiner's consideration.

On May 28, 2002, Applicant filed a second preliminary amendment to add new claims 40-77. The Office Action did not make reference to these claims. Apparently, the preliminary amendment did not get matched with the file prior to the Examiner preparing and mailing the Office Action dated June 4, 2002. Applicant requests consideration of claims 40-77.

SUMMARY OF THE INVENTION

The present invention discloses a novel output choke for a D.C. arc welder. The output choke of the present invention is designed to overcome the limitations of past chokes concerning size, saturation and inflection points. As disclosed in the Background of the Invention (Page 1, ln. 6 - Page 2, ln. 23) and in Figures 2-5, standard large output chokes for arc welders that have a fixed air gap in the core worked well until the output choke experienced high weld currents and core saturation, thereby drastically reducing the inductance. Standard practice to overcome this problem during the welding process was to enlarge the width of the air gap in the core to provide constant inductance over the anticipated operating current range of the welder. As a result, standard output chokes for arc welders were sized and selected for a particular operating current range for a particular welding operation. The width of the air gap of standard output chokes for arc welders was enlarged to reduce the amount of inductance for a particular size of the choke, resulting in the output choke having to be made quite large with large wires to carry the weld current and a large cross sectioned core to prevent saturation. Such output chokes are expensive and drastically increase the weight of the welder.

One prior art output choke design developed to attempt to overcome the problems associated with standard constant width air gap output chokes was a choke having an air gap that included two or three different widths. This alternative prior art output choke produced a high inductance until

the smallest air gap saturated. Thereafter, a lower inductance would be realized until the next larger air gap saturated. By using this alternative prior art choke design, the size of the output choke could be reduced and the range of current controlled by the choke could be increased; however, the choke produced one or more inflection points. As a result, when the feed speed of the electrode or arc length changed to operate in the area of the inflection points, the D.C. welder oscillated about the saturation or inflection points, thereby causing an unstable welding operation. Consequently, the use of multiple stepped output chokes could not be used in arc welders, since the weld current varied too much to operate on the saturation knee of the output choke. Therefore, output chokes having a constant width air gap remain in use for D.C. arc welders.

The novel output choke of the present invention is specifically designed for use in a D.C. arc welder and solves the problems of weight, cost and welding inconsistencies experienced by standard large chokes having a fixed air gap or smaller chokes having a stepped air gap. (Page 3, lns. 2-4). The output choke includes a high permeability core with an area having a cross-sectional shape with two spaced edges and an air gap, wherein the air gap has a gradually converging width between the two edges. (Page 3, lns. 5-7). In one configuration, the air gap of the output choke has a diamond shape; however, other shapes can be used such as, but not limited to, an oval shape or other curvilinear shapes. (Page 3, lns. 8-9; Page 4, lns. 1-3). When a diamond shaped arc gap is used, the diamond shape can be substantially symmetrical (Figures 8 and 14), or non-symmetrical (Figure 12).

The gradually converging air gap width of the output choke produces an inductance in the output circuit of a D.C. welder which gradually varies over the current range in an inverse relationship with the weld current. (Page 3, lns. 9-12; Figure 7). Consequently, as the welding current increases, the inductance decreases in a continuous manner without any discontinuity or

steps. As illustrated in Figures 2-5 and disclosed in the specification, prior art standard chokes have a current-inductance curve that is a straight line relationship between current and inductance, which is substantially constant until the choke becomes saturated and an inflection point occurs. Thereafter, the value is lowered and remains substantially constant until the next inflection point is reached. Consequently, the current-inductance curve of a standard choke does not have a straight line relationship between the current and inductance over a wide current range, nor does the current-inductance curve vary in an inversely proportional relationship to the weld current over a wide current range. The novel choke of the present invention overcomes these past problems of prior art chokes. The weld current is never at a saturation point for the novel output choke, nor does it operate on the saturation knee, thus there is no oscillation of the power to the weld. (Page 3, lns. 12-15). Thus, the output choke of the present invention provides current control over a wide range of weld currents without oscillating or without the need for a large output choke (page 3, lns. 16-18), and without saturation in the air gap, which saturation can cause undesired inflection points that can result in hunting or oscillation of the welder at certain wire speeds and arc lengths. (Page 4, lns. 7-11). By using the output choke of the present invention, a robust welder is obtained that can handle changes, and up to 5-10 volts with arc length changes, without causing instability of the arc. (Page 3, lns. 15-16). The output choke thereby provides current control over a wide range of weld currents without oscillating or without the need for a large output choke. (Page 3, lns. 16-18).

The output choke is specifically designed for use in D.C. arc welders which require a relatively large choke. In such D.C. arc welders, the output choke must be able to handle currents exceeding 50 amperes. Typically, the output choke is designed to handle currents of about 100-500 amperes while still maintaining an unsaturated core. (Page 5, lns. 1-8).

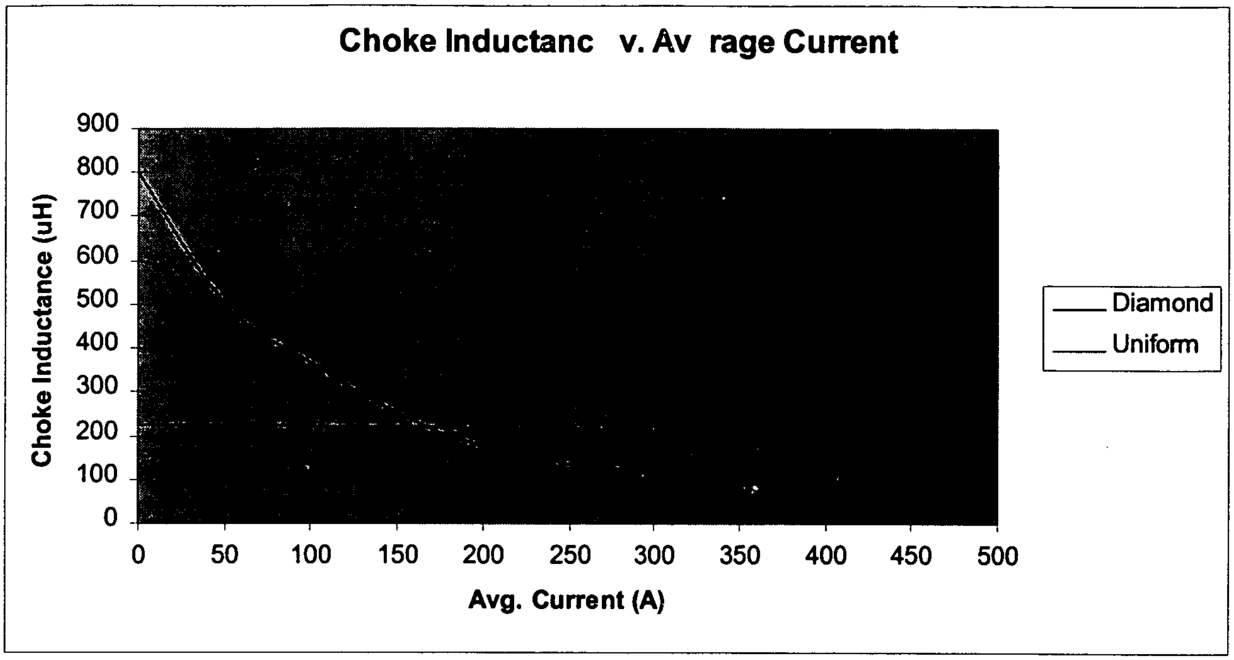
Several non-limiting output choke configurations of the present invention are described in detail on pages 10-12 of the specification. As shown in Figures 6, 8, 12 and 14, the air gap of the output choke is generally diamond shaped. Figures 6, 8 and 14 illustrate the air gap as being substantially symmetrical. Figure 12 discloses the air gap of the output choke as being a generally skewed diamond shape non-symmetrical. Figures 9 and 10 disclose the air gap of the output choke as being generally curvilinear shaped. In each of these air gap configurations, the inductance gradually changes in an inverse relationship with the weld current without saturation in the air gap or any inflection points as shown in Figures 7 and 11.

In each of these output choke designs, the output choke includes a high permeability core 52. The core includes first and second pole pieces (Figure 9 - 300, 302; Figure 10 - 320, 322; Figure 12 - 350, 352; Figure 14 - 402, 404. Note, Figure 8 does not include specific numbers for the two pole pieces), and an inductance controlling air gap (Figure 8 - 58; Figure 9 - 314; Figure 10 - 334; Figure 12 - 338; Figure 14 - 400). The air gap is defined by an end surface on the first and second pole pieces (Figure 8 - 54, 56; Figure 9 - 304, 306; Figure 10 - 324, 326; Figure 12 - 360, 362, 364, 366. Note, Figure 14 does not include specific numbers for the end surfaces on the first and second pole pieces). The end surfaces of the first and second pole pieces face one another and at least a portion of the end surfaces are spaced apart from one another to form the air gap therebetween as shown in Figures 6, 8-10, 12 and 14. The end surfaces of the first and second pole pieces include corresponding outer edges (Figure 8 - 54a, 54b, 56a, 56b; Figure 14 - 406, 408. Note, Figures 9, 10 and 12 do not include specific numbers for the outer edges of end surfaces on the first and second pole pieces). The outer edges are spaced apart substantially the same distance. Figures 6, 8, 9, 10 and 12 illustrate the outer edges as being spaced apart at some positive distance from one another.

Figure 14 illustrates the outer edges as being spaced zero distance apart from one another. In each of these Figures, the outer edges are spaced apart substantially the same distance.

The end surfaces of the first and second pole pieces also include a middle portion positioned between the outer edges. A portion of the middle portion of one pole piece is illustrated by letters a-d in Figure 8. Figures 6, 9, 10 and 12 do not include specific numbers for the middle portion of the end surfaces on the first and second pole pieces. Figures 6, 8, 9, 10 and 12 illustrate that at least a portion of the middle portions of said end surfaces are spaced apart a distance greater than the distance between the outer edges of the end surfaces. As illustrated in Figures 7 and 11 and as disclosed on page 11, lines 2-5, 9-11, 17-20 and page 12, lines 17-20, the air gap of the output chokes illustrated in Figures 6, 8, 9, 10 and 12 results in an inductance that gradually changes with an output current of the welder without saturation in the air gap, thereby eliminating inflection points during operation of the welder.

The novel choke design enables higher inductance at low to mid current ranges, and lowers the inductance at higher current ranges, thereby resulting in better overall welding characteristics. A comparison of the inductance of a standard prior art choke and a novel choke in accordance with the present invention is illustrated in the following graph:



The graph illustrates the inductance verses the current of two chokes. The chokes are identical except for the shape of the air gap. The Diamond line represents a novel choke having a diamond shaped gap in accordance with the present invention. The Uniform line represents a standard prior art choke having a uniform spaced gap. Typically, it takes two complete straight gapped chokes in series to achieve the same inductance that is achieved by the novel choke at about 100 amperes, as illustrated in the graph. An additional benefit of the novel choke is that during the starting of an arc welder, the current rises and the inductance reduces, thus facilitating in the stabilization of the startup of the arc.

As illustrated in the graph, there are no jump discontinuities throughout the welding current range. This is a result of the gradual and continuous gap variation of the novel choke. Such jump discontinuities would be experienced with stepped gap designed, which jump discontinuities destabilize the arc.

It has been found that the higher inductance at low to mid range currents that are achieved by use of the novel choke results in superior welds on stainless steel materials as compared with welds formed by arc welders using standard choke designs. Another benefit of using the novel choke of the present invention is that only half the capacitance is required in the output cap bank to achieve the same arc stability that was previously required when using standard choke designs. Furthermore, equivalent performance has been found when using five (5) turns on the novel choke design with thirty (30) turns on a standard choke design. As a result, the same inductance within a given current range can be obtained with less iron and/or number of conductor turns when using the novel choke design as compared to a standard choke design. This result creates significant advantages as to size, weight and cost when using the novel choke design of the present invention.

THE SECTION 112 REJECTION

A. Section 112(1)

Claims 24 and 26 were rejected under 35 U.S.C. §112(1) because the originally filed Specification failed to disclose an adequate written description of 1) the outer edges of the end surfaces of the pole pieces being connected together to define a non-symmetrical diamond air gap as set forth in claim 26, and 2) the intermediate areas of the end surfaces of the pole pieces having a different shape as set forth in claim 26.

Applicants disagree with the Examiner's rejection. Original Figure 14 and the Specification at pages 8 and 12 disclosed that the end surfaces of the pole pieces can be connected together to define an air gap. Figure 14 discloses that the air gap is a symmetrical diamond shaped air gap; however, the Specification teaches that the invention is not limited to symmetrical diamond shaped air gaps. Furthermore, original claim 8 which depended on original claim 1 included the limitation

that the edges of the first surface touch the edges of the second surface. Original claim 1 did not limit the air gap to any particular shape. Consequently, the originally filed specification provided sufficient support that the inventors, at the time the patent application was filed, had possession of the claimed invention relating to the outer edges of the end surfaces of the pole pieces being connected together to define a non-symmetrical diamond air gap.

Claim 26 has been canceled without prejudice, thereby making the rejection moot.

B. Section 112(2)

Claims 22-39 were rejected under 35 U.S.C. §112(2) as being indefinite.

The Examiner objected to claims 22, 23, 25, 29, 30, 31 and 39 for including the word "substantially" since such word is a relative term. The Federal Circuit has previously held and the MPEP has acknowledged that the word "substantially" can be properly used in claims. See MPEP §2173.05(b).

The Examiner objected to claims 22 and 29 concerning the concepts of 1) the choke inductance gradually changing with an output current of the welder without saturation in the air gap, and/or 2) eliminating inflection points during the operation of a welder. The Specification at page 1, line 7 - page 2, line 23 and page 3, line 8 - page 4, line 23 discloses:

> In D.C. electric arc welders, the output circuit normally includes a capacitor in parallel across the electrode and workpiece with a relatively small inductance for charging the capacitor as the rectifier or power supply provides D.C. current. This inductance removes the ripple from the welding current. In series with the arc gap of the welder there is provided a large choke capable of handling high currents over about 50 amperes and used to control current flow for stabilizing the arc. As the feeding speed of the electrode toward the workpiece and the length of the arc change, the welding current varies. **In the past, the large output ch ke in series with the arc had a fixed air gap in the core to control the inductance at a fixed**

value as current changes. However, when the choke experienced high weld currents, the core saturated and reduced the inductance drastically. For this reason, the width of the air gap in the core was enlarged to provide constant inductance over the operating current range of the welder. The choke was selected for a particular operating current range. However, this range would vary for different welding operations. Thus, the air gap of the choke was selected for the majority of welding operations. **In a standard choke, a small air gap provided high inductance, but would saturate at relatively low currents. To increase the current capacity of the choke, the air gap was enlarged to reduce the amount of inductance for a particular size of the choke.** For these reasons, the choke was made quite large with large wires to carry the weld current and a large cross sectioned core to prevent saturation. The gap was large to accommodate a wide range of welding currents. Such chokes were expensive and drastically increased the weight of the welder. **Further, the choke produced a constant inductance until the saturation point or knee, even though ideal arc welding is realized with an inductance that is inversely proportional to the weld current.** To alleviate these problems, it has been suggested that the air gap could include two or three different widths. This suggestion produced a high inductance until the small air gap saturated. Thereafter, a lower inductance would be realized until the larger air gap saturated. **By using this concept of two, or possibly three, stepped air gaps, the size of the choke could be reduced and the range of current controlled by the choke could be increased. Further, the relationship of current to inductance was inverse. The concept of using a stepped air gap in the core of the output choke allowed a smaller choke; however, one or more inflection points existed. When the feed speed of the electrode or arc length changed to operate in the area of the inflection points, the D.C. welder would oscillate about the saturation or inflection points causing unstable operation.** A standard swinging choke was not the solution because the weld current varied too much to operate on the saturation knee. In addition, such swinging chokes were for small current applications.

The use of a fixed output choke for a D.C. arc welder is now standard. Such choke is large and the operating point is in the linear portion of the inductance preventing drastic reductions in the output inductance of the welder. Such choke is expensive and heavy. **By the procedure of having a stepped air gap, the size of the choke could be reduced and the current operating range**

increased; however, the inflection point at the saturation of one gap, made the welder less robust and susceptible to oscillation at certain arc lengths and feed speeds. Consequently, this suggested modification was not commercially acceptable.

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In the preferred embodiment, the air gap is a diamond shape, gradually increasing from the edges to the center portion of the core. This diamond core technology for the output choke of a D.C. welder **produces an inductance in the output circuit which gradually varies over the current range in an inverse relationship with the weld current.** As the welding current increases, the inductance decreases in a continuous manner without any discontinuity or steps. Thus, **the weld current is never at a saturation point for the output choke or operating on the saturation knee.** There is no oscillation of the power to the weld. This invention produces a robust welder which can handle changes and up to 5-10 volts with arc length changes without causing instability of the arc. Thus, the choke provides current control over a wide range of weld currents without oscillating or without the need for a large output choke.

In accordance with another aspect of the present invention the output choke includes a high permeability core with an air gap defined by first and second pole pieces terminating in first and second surfaces facing each other. Each of these surfaces has two spaced apart edges with an intermediate area with the facing surfaces converging from the intermediate area toward the respective edges of the surfaces to generate a specific cross sectional shape for the air gap. This cross sectional shape is preferably a diamond; however, it may be an oval or other curvilinear shape so long as there is gradual changes in the inductance with changes in weld current. In the preferred diamond shape air gap, the intermediate area is in the center of the pole pieces; however, the intermediate area may be closer to one edge of the facing surfaces. This provides a non-equilateral diamond. In accordance with another aspect of the invention, the gap may have a shape which converges from one edge of the facing surfaces toward the other edge of the facing surfaces. This provides an air gap having the shape of a triangle. **All of these configurations result in a choke where the inductance gradually changes with the output current of the welder without saturation between adjacent areas causing inflection points that can result in hunting r scillation of the welder at certain wire speeds and arc lengths.**

> Another aspect of the present invention is the provision of a method of controlling the inductance in the output circuit of a D.C. electric arc welder operated over a given current range to weld by passing a weld current in the gap between an electrode and a workpiece. This method comprises: providing an inductor with a generally constant inductance over the current range for charging a capacitor connected in parallel with the welding gap or arc; providing an output choke with an **inductance gradually varying over the current range**; and, connecting the choke in series with the gap or arc and between the arc and the capacitor. **In this method, the inductance varies in a generally straight line inversely proportional to the weld current so that as current increases the inductance gradually decreases along a generally straight line.** This is an optimum relationship for arc welding. **Generally straight includes concave or convex linear relationship so long as there is no inflection points along the curve as are caused by stepped air gaps**. (emphasis added).

On pages 8-10 of the Specification, the saturation curves of standard welding chokes are disclosed and described and the saturation curves are illustrated in FIGURES 3 and 5. On pages 10 and 11, the current-inductance curve of the present invention is described and illustrated in FIGURE 7. The patent application discloses that the current-inductance curve is a straight line relationship between current and inductance, which relationship is gradual and continuous. Consequently, there are no inflection points along the curve as compared to the curves illustrated in FIGURES 3 and 5. Furthermore, the current-inductance curve is inversely proportional to the weld current so that as current increases, the inductance gradually decreases. Such a relationship does not exist in standard chokes. As illustrated in FIGURES 2-5 and disclosed in the Specification, prior art standard chokes have a current-inductance curve that is a straight line relationship between current and inductance, which is substantially constant until the choke becomes saturated and an inflection point occurs. Thereafter, the value is lowered and remains substantially constant until the next inflection point is reached. Consequently, the current-inductance curve of a standard choke does not have a straight

line relationship between the current and inductance over a wide current range, nor does the current-inductance curve vary in an inversely proportional relationship to the weld current over a wide current range. Applicant submits that the claim language of claims 22 and 29 is definite in view of the Specification.

Claims 24 and 26 were objected to concerning the a non-symmetrical diamond air gap and the intermediate areas having a different shape. As to claim 24, Figure 12 illustrates a non-symmetrical diamond shaped air gap. Claim 26 has been canceled without prejudice, thereby making the objection moot.

Claim 29 was also objected to concerning the phrase "said winding and said core having a size." The Specification at page 5, lines 1-8 and page 10, lines 6-8 discloses:

> The present invention relates to an arc welder which requires a relatively large output choke. This field is distinguished from power supplies used for low power appliances, such as lights, sound or video equipment. Such miniature power supplies do not have the large currents or the large range of currents needed for arc welding. An arc welder involves currents exceeding 50 amperes. **Indeed, the choke of the present invention is a choke that can handle currents of 100-500 amperes while still maintaining an unsaturated core. The invention handles at least about 100 amperes.** This clearly distinguishes the output choke of the present invention from other inductors used in power supplies.
>
> ********
>
> Choke 50 of FIGURE 1 incorporates the preferred embodiment of the present invention as illustrated in FIGURES 6-8. **Core 50 of high permeability material has a cross section large enough to prevent saturation at over 50 amperes and preferably over 100-500 amperes.** (emphasis added).

The present invention differentiates between chokes used in small electronic devices and chokes used in arc welding machines. Arc welding machines require currents that exceed 50

amperes. Consequently, special chokes are required for arc welding machines. The phrase "said winding and said core having a size" is used in conjunction with the language "to prevent saturation at a weld current of at least about 100 amperes." As the Examiner is aware, the size of the core and/or the number of windings in the core can be reduced by the use of the unique air gap disclosed and claimed in the present invention; however, the core must be of a sufficient size to handle currents of at least 100 amperes. Such a core size distinguishes chokes for arc welders from chokes used for small appliances. Applicants submit that the claim language of claim 29 is definite.

The Examiner objected to claims 31 and 32 for lacking antecedent basis for "diamond shaped air gap." Applicants have amended claims 31 and 32 to correct the antecedent basis problem.

Claim 37 was objected to concerning the phrase "gradually very over a current range in an inverse relationship with a weld current." The language used in claim 37 is definite for the reasons discussed above with respect to claims 22 and 29.

THE SECTION 103 REJECTION

Claims 22-39 were rejected under 35 U.S.C. §103(a) as being unpatentable over Bergman in view of Saitoh and EPO 729040.

The Examiner asserted that Bergman teaches the air gap claimed in the present invention. Applicants disagree. Bergman does not disclose, teach or suggest a diamond shaped air gap as required in claim 22. Bergman discloses a funneled shaped air gap in Figure 5 and a hour-glass shaped air gap in Figure 6. In each of these configurations, the width of the air gap is greatest at one or both side ends of the air gap. Such a teaching is contrary to the claimed invention.

Bergman also does not disclose teach or suggest an air gap defined between the end surfaces of the first and second pole pieces wherein at least one of the intermediate areas of the end surface

is substantially V-shaped, and that the air gap between the end surfaces has a width between the intermediate areas that is greater than the width between either of the outer edges of the first and second pole pieces. As set forth above, Bergman discloses that the width of the air gap is greatest at one or both side ends of the air gap. This teaching is contrary to the limitations of claim 29.

Bergman also does not disclose, teach or suggest the outer edges of the end surfaces of the pole pieces being connected together. The Examiner acknowledges this deficiency of Bergman and cites the teachings of Saitoh in an attempt to address this deficiency. Saitoh discloses two pole pieces being connected together; however, **there is no air gap** disclosed in Saitoh. Consequently, the teachings of Saitoh are contrary to the teachings of the choke disclosed and claimed in the present invention.

The Examiner also asserted that the EPC patent discloses a choke having a diamond shaped gap. The EPC patent does not disclose or even pertain to a choke. The EPC patent only discloses a passive electronic marker that uses a plurality of ferrite cores. The range and frequency of the marker are achieved by the air gap between the cores. Consequently, the teachings of the EPC patent in combination with Bergman and/or Saitoh do not make obvious the claimed invention.

Applicants submit the claims presently pending in the above-identified patent application are in condition for allowance and a notice to that effect is earnestly solicited. Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment.

The attached page(s) are captioned "**VERSION WITH MARKINGS TO SHOW CHANGES MADE.**"

Respectfully submitted,
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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Page 1 of the application has been replaced with the following new page 1:

OUTPUT CHOKE FOR D.C. WELDER
AND METHOD OF USING SAME

This patent application is a continuation of United States Patent Application Serial No. 09/534,583 filed March 27, 2000, which in turn is a continuation of United States Patent Application Serial No. 09/184,149 filed November 2, 1998, now abandoned.

The present invention relates to an output choke for a D.C. arc welder and a method of controlling the inductance in the output circuit of a D.C. electric welder using such choke.

BACKGROUND OF INVENTION

In D.C. electric arc welders, the output circuit normally includes a capacitor in parallel across the electrode and workpiece with a relatively small inductance for charging the capacitor as the rectifier or power supply provides D.C. current. This inductance removes the ripple from the welding current. In series with the arc gap of the welder there is provided a large choke capable of handling high currents over about 50 amperes and used to control current flow for stabilizing the arc. As the feeding speed of the electrode toward the workpiece and the length of the arc change, the welding current varies. In the past, the large output choke in series with the arc had a fixed air gap in the core to control the inductance at a fixed value as current changes. However, when the choke experienced high weld currents, the core saturated and reduced the inductance drastically. For this reason, the width of the air gap in the core was enlarged to provide constant inductance over the operating current range of the welder. The choke was selected for a particular operating current range. However, this range would vary for different welding operations. Thus, the air gap of the choke was selected for the majority of welding operations. In a standard choke, a small air gap provided high inductance, but would saturate at relatively low currents. To increase the current capacity of the choke, the air gap was enlarged to reduce the amount of inductance for a particular size of the choke. For these reasons, the choke was made quite large with large wires to carry the weld current and

Page 7 of the application has been replaced with the following new page 7:

BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 is a schematic wiring diagram of a D.C. arc welder having an output circuit using the present invention;

FIGURE 2 is a pictorial view showing schematically a standard, prior art output choke for a D.C. welder;

FIGURE 3 is a current-inductance graph showing the saturation curves for various air gaps used in the prior art choke schematically illustrated in FIGURE 2;

FIGURE 4 is a pictorial view showing schematically an output choke for a D.C. welder which has been suggested for correcting the problems of the prior art choke illustrated schematically in FIGURE 2;

FIGURE 5 is a current-inductance graph showing the saturation curve for the choke illustrated schematically in FIGURE 4;

FIGURE 6 is a pictorial view of an output choke for a D.C. welder constructed in accordance with the preferred embodiment of the present invention;

FIGURE 7 is a current-induction graph for the preferred embodiment of the present invention as illustrated in FIGURE 6;

FIGURES 8, 9 and 10 are partial views of the core and air gaps having shapes using the preferred embodiment of the present invention;

FIGURE 11 is a current-inductance graph similar to FIGURE 7 showing the operating curve for the embodiments of the invention shown in FIGURE 8-10;

FIGURES 12 and 13 are partial view of the core of the choke showing air gaps having shapes which are modifications of the preferred embodiments of the present invention as shown in FIGURES 8-10; [and,]

<u>FIGURE 12A is a modification of FIGURE 12 wherein the air gap shape is obtained by two core pieces which touch each other;</u>

Page 8 of the application has been replaced with the following page 8:

FIGURE 14 is a partial view of the core of an electrode constructed in accordance with the present invention wherein the preferred diamond air gap shape is obtained by two core pieces which touch each other and are affixed[.]; and,

FIGURE 14A is a partial view of the core of an electrode constructed in accordance with the present invention wherein the preferred diamond air gap shape is obtained by two core pieces which touch each other and are affixed and a low permeable material fills the air gap.

PREFERRED EMBODIMENTS

Referring now to the drawings, wherein the showings are for the purpose of illustrating preferred embodiments of the invention only and not for the purpose of limiting same, FIGURE 1 shows a D.C. electric arc welder 10 capable of creating a welding current of at least about 50 amperes and up to 200-1,000 amperes. Power source 12, shown as a single phase line voltage, is directed through transformer 14 to rectifier 16. Of course, the rectifier could be driven by a three phase power source to create a D.C. voltage. In accordance with standard practice, a capacitor 20 having a size of about 20 K-150 K micro farads is charged by inductor 22 having a size of approximately 20 mH. Rectifier 16 charges capacitor 20 through inductor 22, which inductor may be replaced by inductance of the transformer. Output voltage from rectifier 16 at terminals 24, 26 is the voltage across capacitor 20 that maintains a voltage across arc gap *a* between electrode 30 from a wire feeder 32 and workpiece 34. To maintain an even flow of current across arc *a*, a relatively large output choke 50 is provided in the output circuit between capacitor 20 and gap or arc *a*. The invention involves the construction and operation of current control output choke 50, as best shown in FIGURE 6. In the past, output choke was a large choke as schematically shown in FIGURE 2 wherein choke 100 has a high dependability core 102 with an air gap g defined between two facing surfaces 104, 106. The high currents demand large wires for winding 110. To obtain high inductance, the number of turns is high. To prevent saturation the cross section of core 102 is large. Thus, choke 100 is large, heavy and

Page 12 of the application has been replaced with the following new page 12:

352 with facing surfaces having converging portions 360, 362 and 364, 366. These portions

define a large air gap area 338, which area is slightly offset from the center of the core. FIGURE 12A is a modification of FIGURE 12 wherein the air gap shape is obtained by the two core pieces 350, 352 touching each other. Another asymmetric air gap configuration is shown in FIGURE 13 wherein core 52b includes pole pieces 370, 372 with a angled surface 374 and a straight surface 376. The air gap shown in FIGURE 13 is also accomplished by forming pole piece 370 with a flat perpendicular surface, but tilting it with respect to pole piece 372. These structures produce an air gap with a small portion on the left and a large portion on the right. These two asymmetric air gaps produce better results than the stepped air gap 210 in FIGURE 4; however, they do not obtain the desirable effects shown in FIGURE 11 as accomplished by the symmetric air gap configurations shown in the preferred embodiments of FIGURES 8-10.

In practice, choke 50 has a core as illustrated in FIGURE 14. A diamond shaped symmetrical air gap 400 is provided between pole pieces 402, 404 with the abutting edge portions 406, 408 touching each other to define the intermediate air gap 400 with small gap portions 412, 414 gradually increasing to a large gap portion 414. Pole pieces 402, 404 are joined by a strap 420 using appropriate pins 422, 424. Air gap 400 is a diamond shaped air gap, which air gap is large at the apex or center and decreases toward both edges of the core. This diamond shaped air gap provides a generally straight line, inversely proportional relationship between current and inductance, which relationship is optimum for electric arc welding. A low permeability potting material 416 can fill air gap 400 as illustrated in FIGURE 14A when the choke is packaged for use in the field.

IN THE CLAIMS:

Claims 26, 34 and 57 have been canceled without prejudice.

Claims 22, 28, 29, 31, 32, 40, and 58 have been amended as follows:

22. (Amended) An output choke for a D.C. arc welder having an inductance comprising a high permeability core having first and second pole pieces and an inductance controlling air gap, said first and second pole pieces each having and end surface, said air gap

defined between said end surfaces of said first and second pole pieces, each end surfaces including two outer edges and an intermediate area positioned there between, each of said intermediate areas being substantially V-shaped, said outer edges of said end surfaces of said first and second pole pieces being connected together and a diamond shaped air gap is formed by said two intermediate areas, said air gap having a configuration which results in said inductance of said choke [gradually] changing with an output current of the welder without saturation in said air gap thereby eliminating inflection points during operation of said welder.

28. (Amended) The output choke as defined in claim 22, wherein said choke includes [a] at least one winding for conducting welding current, said at least one winding and said core [has] having a sufficient size to prevent saturation at a weld current of at least about 100 amperes.

29. (Amended) An output choke for a D.C. arc welder having an inductance comprising a high permeability core having first and second pole pieces, an inductance controlling air gap, and [a] at least one winding for conducting welding current, said first and second pole pieces each having and end surface, said air gap defined between said end surfaces of said first and second pole pieces, each end surfaces including two outer edges and an intermediate area positioned there between, at least one of said intermediate areas being substantially V-shaped, said air gap having a width between said intermediate areas of said first and second pole pieces that is greater than a width between either of said outer edges of said first and second pole pieces, said air gap having a configuration which results in said inductance of said choke gradually changing with an output current of the welder without saturation in said air gap thereby eliminating inflection points during

operation of said welder, said <u>at least one</u> winding and said core having a size to prevent saturation at a weld current of at least about 100 amperes.

31. (Amended) The output choke as defined in claim 29, wherein said [diamond shaped] air gap is <u>diamond shaped</u> [substantially symmetrical].

32. (Amended) The output choke as defined in claim [29] <u>31</u>, wherein said diamond shaped air gap is [non-symmetrical] <u>substantially symmetrical</u>.

40. (Amended) An output choke for a D.C. arc welder having an inductance and adapted to include at least one winding for conducting current, said output choke comprising a high permeability core having first and second pole pieces and an inductance controlling air gap, said first and second pole pieces each having and end surface, said air gap defined between said end surfaces of said first and second pole pieces, each end surfaces including inner and outer edges and a middle portion positioned there between, at least one of said middle portions being substantially V-shaped, <u>said air gap having a width between said middle portions of said end surfaces of said first and second pole pieces that is greater than a width between at least of said inner edges or outer edges of said end surfaces of said first and second pole pieces,</u> said air gap having a configuration which results in said inductance of said choke changing with an output current of the welder without saturation in said air gap thereby eliminating inflection points during operation of said welder.

58. (Amended) An output choke for a D.C. arc welder having an inductance and